XXI.—*A Descriptive List of the* Uredineæ *occurring in the Neighbourhood of Simla (Western Himalayas).*—*By* A. Barclay, M. B., *Bengal Medical Service.*

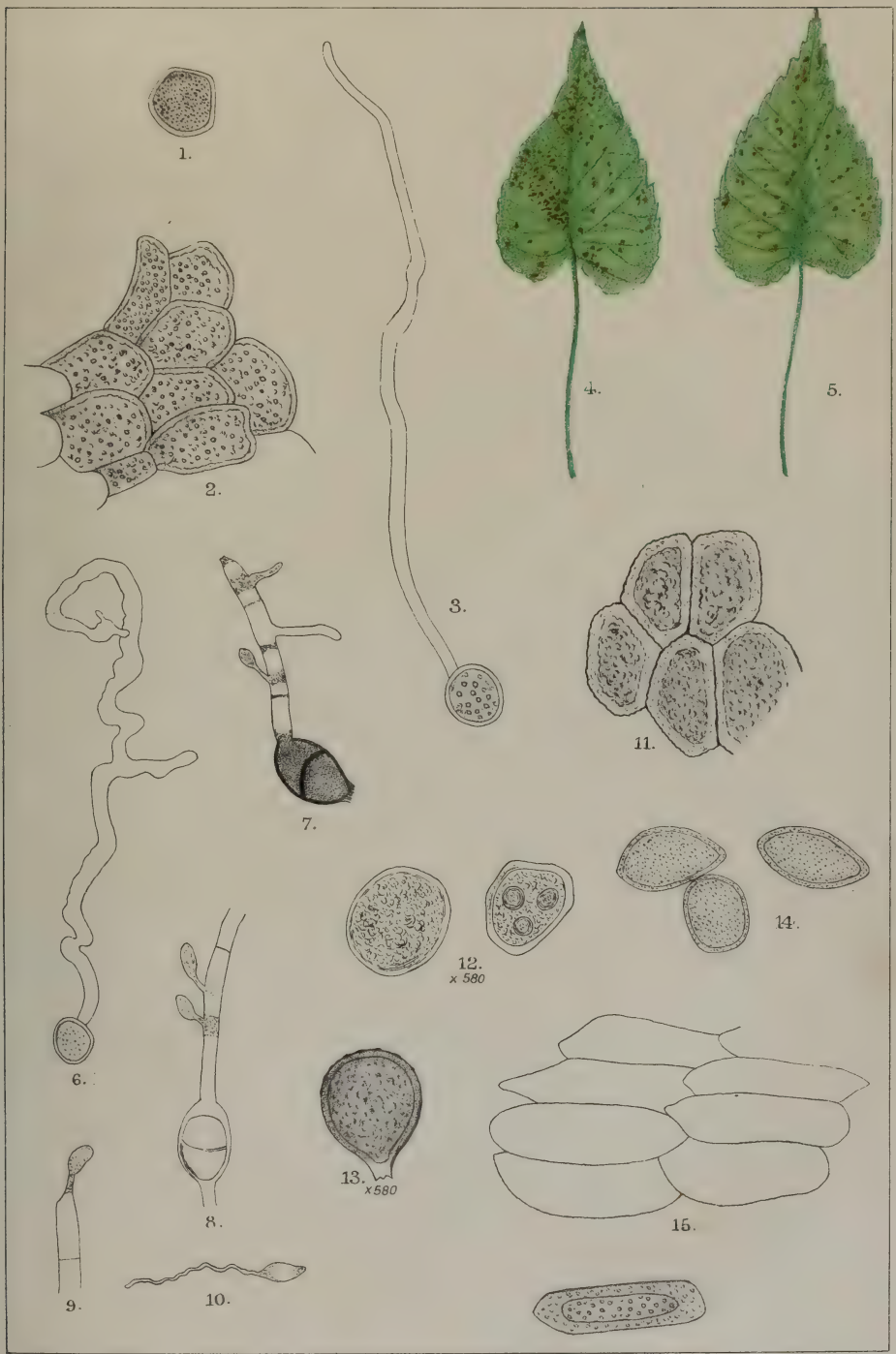
[Received 7th October;—Read November 2nd, 1887.]

(With Plates XII.—XV.).

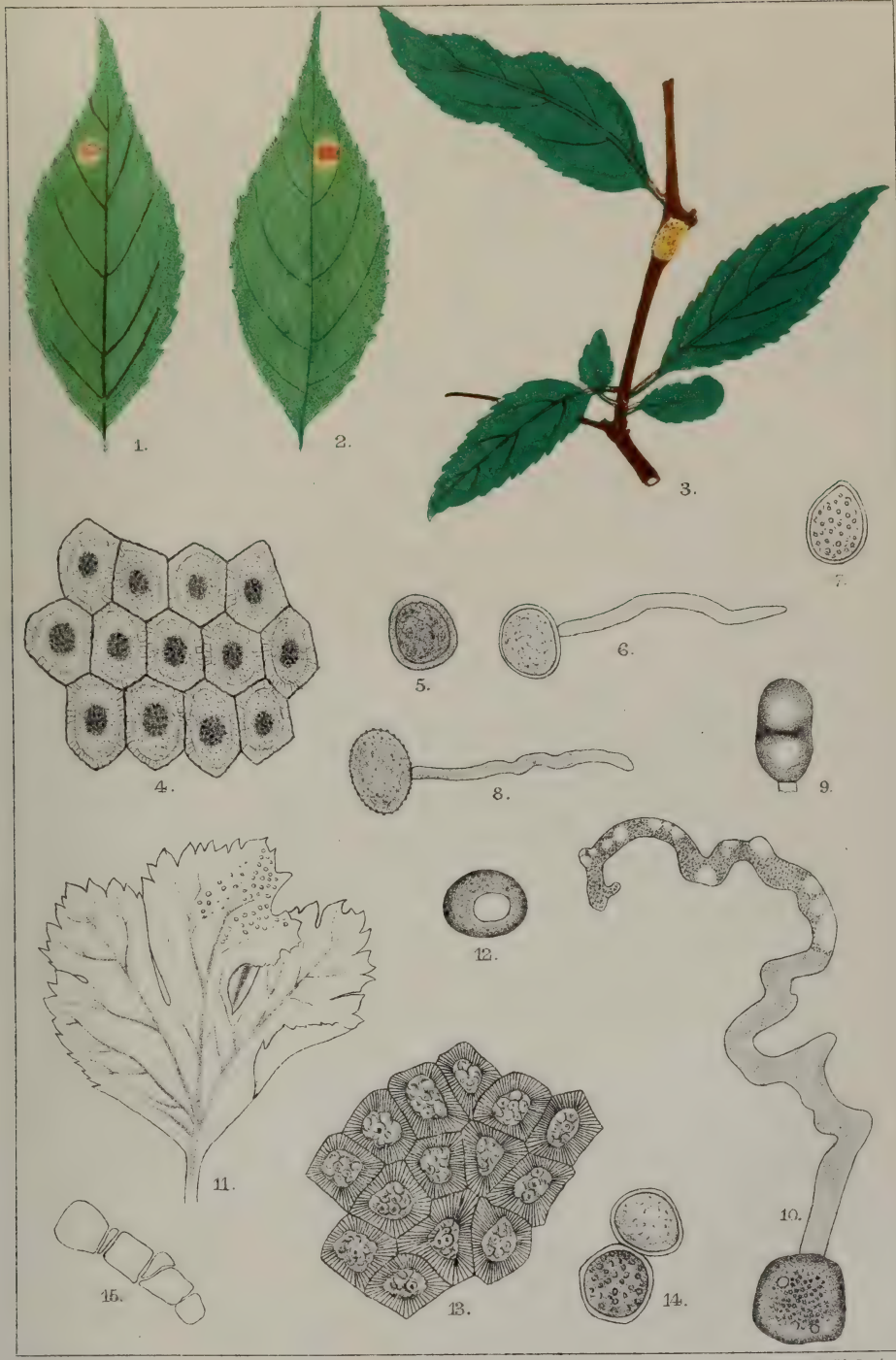
The neighbourhood of Simla is particularly rich in species of Uredines; and, as I have paid much attention to them during the last four years, it has been suggested to me that a descriptive list of them might usefully be recorded for the use of future workers in this very interesting field of cryptogamic botany. I have acted on the suggestion after much hesitation, for, with the very limited leisure at my disposal in the course of an active official life, I cannot hope to make the list a complete one, nor, indeed, can the descriptions of many of those I notice be as complete as might be desired. Nevertheless, so far as they go, my statements may, I hope, be accepted as correct in every respect, for every one of them has been made after careful and repeated observation. I may, therefore, be permitted to hope that the list may serve some useful purpose, more especially as no such attempt has ever before been made in India, so far as I am aware.

With regard to the order in which such a list should be given, I have determined, after some hesitation, to bind myself by no very strict rule, but, in general, to enumerate, first, all those species which bear æcidial fructification and, then, to go on to those which are at present known to me only in the teleutosporic stages. With reference to the æcidium-bearing species, I may note that I have described them generally as they occur in seasonal sequence, beginning with those which appear earliest in spring, and ending with those which disappear last towards autumn. The only exception I have made in following out this plan is to withdraw from the general list all those forms which occur on the Coniferæ, as I thought it better to enumerate the characters of these few well defined species together, rather than to disperse them among the others, which occur on hosts having no special relationship with one another.

In the present contribution, I will confine myself to the æcidial forms with which I am acquainted on hosts other than the Coniferæ; but, before proceeding to a description of them, I may draw the attention of the reader to one or two points of special interest concerning them.



A.Barclay, del.
Parker & Coward, lith.
West, Newman & C° chr. imp.



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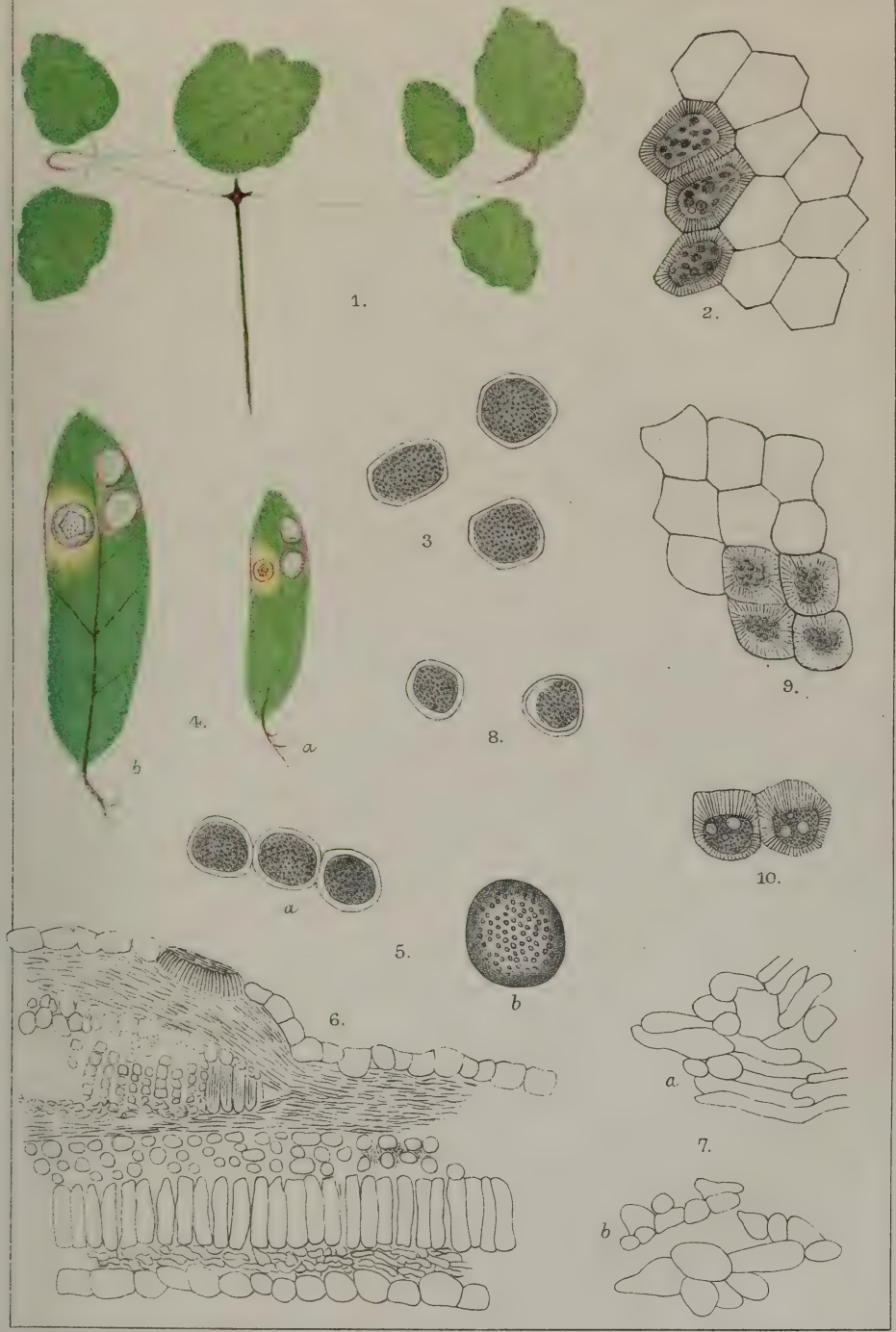

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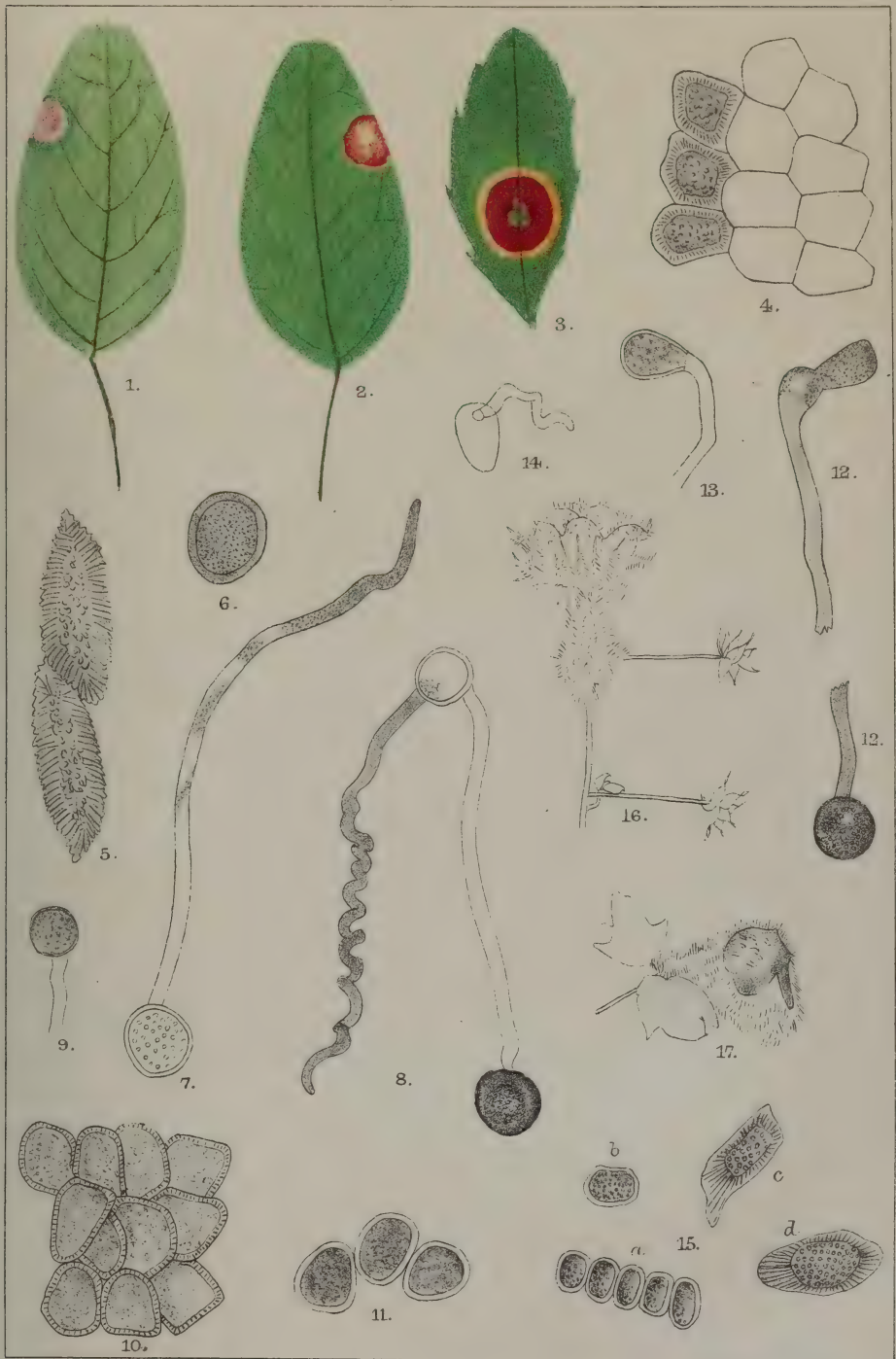

A. Barclay, del.
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In the first place, it will be observed that I have related several of them with a mark of interrogation to species already described as occurring in Europe. Until the complete life-histories of these are known, it is impossible to state definitely whether they are correctly so related or not. They are probably all varieties of, or identical with, the European forms with which I have associated them. In only one case (that of *Æcidium Urticæ*, Schum.) has the life-history of the Indian variety been fully traced.

Five of the species described are I believe quite new, in only one of which *(Æcidium Strobilanthis)* have I been able to trace the whole life-history. That on the wild strawberry (*Fragaria vesca*) appears to be a complete autoecious Uredine, but I have unfortunately not been able to prove this by actual experiment. And, in this connection, I would again draw attention to the inconvenience caused by the system of nomenclature now adopted of naming species of Uredines after their teleutosporic forms, an inconvenience which it appears to me will increase as our knowledge of this family is extended, for it sometimes happens that a host bearing an æcidium bears also a teleutospore, which, however, has no relationship whatever with the æcidium. For example, according to this principle, I have been obliged to name the Æcidium which occurs on *Valeriana Wallichii Uromyces Valerianæ*, although I have abundant evidence that the teleutospores have no genetic relationship whatever with the Æcidium. In all probability, future investigation will show that the Uromyces borne on this host is related to some other Æcidium on an entirely different host, whilst the teleutospores borne on some other host are related to the Æcidium on the Valeriana in question. In the cases of *Strolilanthes Dalhousianus* and *Urtica parviflora*, which bear Æcidia whose complete life-histories are known, teleutospores (puccinia) are also borne, which, however, have no relationship with the Æcidia.* The Æcidium on *Jasminum revolutum* presents no unusual features, but those on *Euphorbia cognata* and *Andrachne cordifolia* display aberrant features of great interest. Indeed, these two Æcidia differ so markedly from all others that I have regarded them, provisionally, and until I shall have had further opportunities of working out their complete life-histories, as belonging to a new genus, which I propose calling Monosporidium.

With these introductory remarks I shall pass on to a description of the several species.

* *See* "Scientific Memoirs by Medical Officers of the Army of India," Part II, Calcutta, 1887.

I.—ÆCIDIAL FORMS.

1.—Æcidium Saniculæ, sp. nov.

Sanicula (Europæa, L. ?)

The earliest Æcidium which I have observed in Simla is that which occurs on *Sanicula Europæa*. Towards the latter end of March, some of the earliest leaves of this plant which are being unfolded in spring may be found attacked by this parasite. It is by no means an uncommon fungus. The invaded areas of the leaf are usually small, and generally convex below, where the aecidial cups are usually borne, though a few may open also on the upper surface of the leaf. The æcidia discharge their spores through a *porous* like opening at their summits, *i. e.*, the peridium does not open widely as in most cases with the fragments of the torn tissue forming a *stellate* opening. The petioles are also frequently attacked and at such places they are thickened and often bent. A single leaf blade may present from one to three patches of invasion, these patches being slightly paled in colour as seen from the upper surface.

Æcidiospores.—The moistened æcidiospores measure on an average 25·4 × 19·4 μ, the measurements exhibiting extremes of 26 μ in length and 20 μ in breadth. The epispore is finely punctated and contains from two to three germ pores. The endospore is very fine and not readily distinguishable from the epispore (Fig. 1, Pl. XII.). The spores, when placed in water under suitable circumstances, readily germinate, throwing out long curved tubes measuring 6 to 7 μ in diameter. Only one germinal tube is produced by each spore. The peridial cells measure about 30 × 22 μ (Fig. 2, Pl. XII.).

Remarks.—This æcidium is, I believe, a new species ; but may be compared with that which I have described below on *Pimpinella diversifolia.*

2.—Uromyces Valerianæ, Schum ?

Valeriana Wallichii, D. C.

Next to the foregoing Æcidium one on this plant is among the earliest of these parasites to be found in spring. Towards the end of March, some plants may be found in initial stages of attack ; but it is towards the latter part of April that it is seen in its fullest development. This Æcidium is one of the most common and abundant in Simla, and individual plants are often so extensively affected in blade and petiole as to be completely destroyed. The affection is usually confined to the blades and petioles of the radical leaves, but may also be found on the upper leaves of the flowering stalks and even, though rarely, on the bracts of the flower heads. When a leaf is extensively affected, it is considerably distorted, and the parts actually

invaded by the mycelium are considerably thickened. At an early stage of the affection, patches of pale yellow discoloration may be observed on the leaf blades, which are usually convex above. On this upper convex surface, a few spermogonia may be seen, whilst the æcidial fructification usually emerges from the lower or concave side. The æcidia consist of short tubular peridia filled with reddish yellow spores bursting at their summits in a stellate way.

The spermoginia are remarkably few and their mouths are surmounted by a tuft of paraphyses.

The æcidial affection above described is met with abundantly throughout the time the plants are in flower, but, as soon as the seeds are being matured, towards the middle or end of May, this affection disappears entirely. After an interval of some weeks from the time the æcidial parasite has entirely disappeared, these plants are seen to be attacked by a teleutospore-bearing mycelium also mainly on the radical leaves, though occasionally also on others. This affection always appears on leaves which bear no trace of formerly having borne the æcidial parasite. The spores are extruded from dark brown pustules of minute size, which usually occur in great numbers on each affected leaf. Each pustule is surrounded by a zone of yellow discoloration. At first, these spores are extruded only from the upper surface of the leaf, but later also from the lower surface, exactly opposite the site of the upper spore bed and therefore from the same mycelium. The lower pustule is usually smaller than the upper. At first, when a spore pustule exists only in the upper surface of the leaf, the affected area bulges upwards (convex upwards) with a corresponding concavity below; but this disappears when the lower surface is also involved in spore extrusion.

Æcidiospores.—These are abstricted serially from basidia arranged on a flat hymenium. They are pale orange-yellow round or oval bodies measuring, when dry, 17 × 15 μ and, after lying some time in water, 22 × 20 μ (Fig. 12, Pl. XII.). The epispore is smooth and unmarked. They do not germinate readily in water (Fig. 10, Pl. XIII.). The peridium consists of a layer of single cells.

Teleutospores.—These are brown single-celled bodies—Uromyces—borne singly on stalks (Fig. 13, Pl. XII.). They are somewhat pear-shaped, measuring when moist 25 × 22 μ, and the stalks bearing them are about twice the length of the long diameter of the spore. The spores are readily detached from their beds without any portion of the stalk adhering to them. The epispore is firm and resistant and a little thickened towards the base, where it joins the stalk. It is sparsely beset externally with tubercles. A few fine paraphyses usually occur

among the spores. Most spores exhibit a nuclear space or body in the centre. Although I placed them in several nutritive solutions and in water, I never observed them germinating.

Remarks.—I have made very numerous experiments with the view of tracing the life-history of this very common Æcidium, but without success. I am quite convinced that the teleutospore-bearing fungus has no connection whatever with that bearing the æcidium, not only because many carefully conducted experiments failed to establish any such connection, but also because a considerable interval elapses, as I have already noted, between the complete disappearance of the Æcidium and the appearance of the teleutospores. I have also attempted to reproduce the Æcidium by inoculating leaves with almost every teleutospore with which I am acquainted, and most of which I hope to describe later in this series.

This fungus may be identical with *Uromyces Valerianæ*, Schum, in which the æcidiospores are stated to measure 17 × 24 μ and the Uromyces spores, 20 to 26 by 15 to 19. The latter fungus, however, also possesses uredospores, which are entirely absent in the Himalayan species.

3.—Puccinia Violæ, Schum ?

Viola serpens, Wall.

An Æcidium of a very destructive kind is extremely common on *Viola serpens* in spring (April) and occurs simultaneously with that described on Valeriana. As a rule, large areas of the leaves become affected and very frequently the petiole also is extensively involved. Sometimes there is scarcely a portion of the whole leaf, blade and stalk, which is not involved, and, in such cases, the whole leaf speedily succumbs to the parasite. In such extreme cases, the blade of the leaf is crumpled up almost beyond recognition, while the affected stalk is bent in various directions and considerably hypertrophied. Limited patches on the leaf blade are generally round and very deeply bulged downwards, *i. e.*, with a concavity upwards. The æcidia are borne most usually on the under surface of the leaf, but a few burst forth also from above. But little discoloration is caused by the mycelium on the upper surface of the leaf, which is only slightly paled.

Later in the season, about the beginning of June, when the æcidial fungus has disappeared, the new leaves of the violet are often attacked by another puccinia-bearing parasite. Many leaves may now be found, in the same localities where formerly the æcidial parasite was common, studded with numerous dark brown or black pustules of the size of a small pin's head, mostly on the under surface. These pustules are irregularly scattered over the leaf blade, bursting through the epi-

dermis (after having raised it considerably) by a clean rent. Opposite the pustules, on the upper surface of the leaf, small greenish yellow spots may be seen. Although the greater number of pustules emerge from the lower surface, yet many also burst forth from the upper surface, especially when the leaf is very largely attacked (Figs. 4 & 5, Pl. XII.).

It has been stated above that these puccinia-pustules are usually borne on newly unfolded leaves, but, in one or two instances, I found the dried up remains of *æcidial* patches on the petioles of leaves which bore these teleutospores. This observation naturally led me to think that the two forms were genetically related, and I accordingly made numerous attempts to establish the relationship upon experimental grounds, but always without success. I am therefore inclined now to regard the two parasites as entirely distinct, and I am supported in this view here, as in the case of Valeriana above, by the fact that, as a rule, a distinct interval of about a month or more elapses between the complete disappearance of the æcidium and the appearance of the teleutospores; and it is quite exceptional to find any trace of old æcidia on plants bearing the puccinia-producing mycelium. I may here note that I have made numerous attempts during the last two years to connect the Æcidium on the violet with several teleutospores occurring on various plants in Simla, but, as in the case of the even more common Valeriana Æcidium, always without success.

Æcidiospores.—When well moistened in water, the spores measure 21 × 18 μ, but, when dry or immediately after immersion in water, they measure on an average 19 × 14·8 μ. They readily germinate in water, throwing out a single more or less sinuate tube measuring about 6 μ in diameter (Fig. 6, Pl. XII.). This germ-tube has a tendency to throw out short lateral branches. The orange-red contents of the spore wander into the furthest end of the tube. The spores appear to have 3 to 4 germinal pores, but only one germ-tube is formed by each.

Teleutospores.—These are dark brown puccinia easily detached from their beds without any portion of the stalk remaining adherent (Fig. 7, Pl. XII.). When dry, these spores measure as follows:—whole length, 30 μ; length of upper cell, 14 μ; length of lower cell, 16 μ; breadth at septum, 18 μ. The spores are somewhat thickened at their free ends, sometimes to the extent of 4 μ. Among these puccinia-spores, a few single-celled spores were often found which may have been either uredospores or a second form of teleutospore. They are brown bodies with thick resistant walls covered externally with prominent tubercles. They measure, when dry, 20 × 18 μ on an average: I never observed their germination. Some freshly collected spores were

placed in water in a growing cell on the 20th March, and they germinated freely, although some spores preserved in botanical drying paper since the previous autumn had lost vitality (Figs. 7 & 8, Pl. XII.). The promycelium from the upper cell emerges from the apex, whilst that from the lower cell emerges from a point close to the septum. The promycelium produces four sporidia from four cells into which the end of the promycelium is divided, the most distant one being produced upon a sterigma arising from the very apex of the germ-tube (Figs. 7, 8, 9, Pl. XII.). The sporidia are oval, measuring from 6 × 4 μ to 7 × 5 μ (Fig. 10, Pl. XII).

Remarks.—It is possible that this fungus is identical with, or, more probably, a variety of, *Puccinia Violæ*, Schum., although the measurements of the latter given by Winter* do not agree with mine very nearly. Winter's measurements are as follows:—æcidiospores 16 to 24 μ by 10 to 18 μ (average 20 × 14 μ) against my measurement of 21 × 18; uredospores 19 to 26 μ in diameter against my measurement of 20 × 18 μ; teleutospores 20 to 35 μ by 15 to 20 μ (average 27·5 × 17·5) against my measurements of 30 × 18 μ. The characters of the teleutospores as given by Winter agree with those of mine.

4.—Puccinia Pimpinellæ, Strauss.

Pimpinella diversifolia, D. C.

The next æcidium which attracts attention is not so common as those above described, and occurs on *Pimpinella diversifolia*. This parasite may be found in certain localities towards the end of April or the beginning of May, and is very soon after that missed again. Indeed, towards the end of May, it has already become very scarce. The fungus usually attacks the first leaves that are unfolded of this plant, these being simple leaves of the shape of the common violet leaf. The compound leaves later unfolded were very rarely found attacked. The invaded areas of leaves are discoloured, becoming pale yellowish green, and the æcidia are borne almost wholly on the under surface, though a few occasionally break through the upper surface. The æcidial fruit consists of tubular peridia measuring about 2 to 2·25 m.m. in length which burst at their summits in a stellate manner. In addition to the leaf blade, the petiole is not unfrequently attacked, and here the peridial tubes are somewhat longer than they are on the leaf blade. Several distinct patches of æcidia sometimes occur on a single petiole, but in such cases the blade is also largely affected. At these places on the petiole the tissues are somewhat hypertrophied. The leaf blade also where invaded is thickened, the depth of the laminal tissues at

* Die Pilze Deutschlands, &c. Von Dr. George Winter.

such places being about 0·441 m.m., whilst the normal thickness is about 0·239 m.m.

A little later, towards the end of May, when the æcidial parasite is becoming rare, some of the compound leaves (never the simple ones) may be found attacked by a separate mycelium bearing uredospores. This uredospore-bearing mycelium is never found on the same leaf bearing æcidiospores, and it is therefore quite probable that the two mycelia are in no wise genetically related to one another. The uredo-pustules are minute, circular, and saffron-coloured, mostly on the upper surface of the leaf, though by no means infrequently also on the lower. Sometimes the upper surface of a leaf may be seen to be densely covered with these uredo-pustules.

Again in autumn, about the end of September and October, the same plant may be seen largely affected by a puccinia-bearing fungus, a distinct interval having elapsed since the disappearance of all trace of the uredo-bearing fungus. These puccinia-pustules are minute and round, like the uredo-pustules, but black, and occur both on the upper and lower surfaces of the leaves, sometimes in great profusion. The stem is also often affected; the pustules here are linear, their long axes corresponding with the long axis of the stem.

The *æcidiospores* are reddish yellow with very thin walls, the epispore and endospore not being distinguishable from one another: they are round, oval, or somewhat fusiform (Fig. 14, Pl. XII.). The round spores measure 20 to 21 μ in diam., the oval about 32 × 20 μ, and the fusiform about 38 × 14 μ, shortly after being wetted with water.

The *spermogonia* are likewise situated on the under surface of the leaf: they measure about 0·163 m.m. in depth and 0.189 m.m. in breadth. Their mouths are beset with paraphyses projecting about 0.063 m.m. The spermatia are round or oval and measure 4 × 3 μ.

The *peridium* consists of elongated cells, very unlike those of the æcidium on Sanicula described above, measuring about 60 × 20 μ, and easily detached from one another by teasing (Fig. 15, Pl. XII.).

Uredospores.—These are reddish yellow round or oval bodies with coarse tubercles on the surface of the epispore. On an average, the moistened spores measure 22 × 18·3 μ. They germinate readily in water. (Fig. 3, Pl. XII.).

Teleutospores.—These are brown two-celled bodies (puccinia) readily detached from their beds with a very small portion of the stalk remaining adherent to them. In each cell, a clear nuclear body or space may be seen. The epispore is marked externally by fine ridges. They are not thickened at their free ends. As with the uredospores, I never succeeded in getting them to germinate in water. Their measurements

are as follows :—whole length of spore 30 μ; length of lower cell 13 μ and of upper cell 17 μ; breadth at septum 23 μ; extreme breadth of upper cell 24 μ and of lower cell 22 μ.

Remarks.—At first it seemed extremely probable that all the three forms above described were phases of one fungus, and I attempted frequently to establish a relationship between them by experiment, but always without success. This alone, however, does not justify me in definitely denying a relationship between them, since it is quite possible that some condition of my experiments militated against the manifestation of a relationship. However, the experiments were carefully conducted and often repeated. I also attempted to reproduce the æcidium by laying the teleutospores found on several grasses in the neighbourhood on the young leaves; but in these attempts also I failed.

This parasite is probably identical with *Puccinia Pimpinellæ*, Strauss, in which the æcidiospores are said to measure 18 to 35 μ long and 16 to 21 μ broad (average 26·5 × 18·5 μ), the uredospores, 23—32 μ long and 19 to 24 μ broad (average 27·5 × 21·5), and the teleutospores, 26 to 35 μ long and 17 to 26 μ broad (average, 30·5 × 21·5). The only feature in which this fungus differs from that which I have described is in the characters and size of the uredospores. In Strauss's plant the uredospores are said to be pale brown, while in mine they are reddish yellow and smaller.

5.—Puccinia coronata, Corda ?

Rhamnus dahuricus, Pall.

The Æcidium which occurs on this plant is not very common, although occasionally an attacked tree or bush is very extensively affected. The fully ripe æcidium may be found as early as the latter part of May, but it is more usually met with about the middle of July. The fungus attacks leaves, young stem (Figs. 1, 2, 3, Pl. XIII.), and drupes, the last sometimes very extensively indeed. When the leaf is attacked, the invaded areas are usually small, and generally only one patch occurs on each leaf. These patches are dark reddish brown above, surrounded by a halo of pale yellow (Fig. 2, Pl. XIII.), and the orange-yellow æcidia are borne on the lower or concave surface of the leaf, opposite the dark central part seen above (Fig. 1, Pl. XIII). The red colour of the patch is due especially to discoloration in the palisade cells, and the abnormal thickness to hypertrophy of the spongy tissue, the palisade cells retaining their normal dimensions and characters. The tissues in the areas invaded are very extensively permeated by hyphæ, and many cells are destroyed. While the thickness of the leaf blade is normally 0·126 m.m., it is about 0·440 m.m. in patches bearing ripe

æcidia. A patch of ordinary size measured 1 c.m. in total diameter, the central reddish brown part measuring 6 m.m. in diameter. The patches are sometimes considerably larger, however, and more irregular in shape. The æcidia are tubular structures, very deeply sunk into the laminal tissue, measuring about 1·75 m.m. in length, and therefore resembling in some degree the Æcidium on *Pyrus variolosa* described below. With very few exceptions, the æcidia burst from the lower surface of the leaf. These patches on the leaves are often placed near the margin of the leaf, and are usually between and not over the principal veins; but when a vein is involved it is considerably thickened. When the stem is attacked, which occurs but rarely, it is considerably swollen. The drupes when attacked are often densely covered with æcidial tubes, set at right angles, all over them.

The *spermogonia* are formed on both the upper and lower surfaces of the patches, and may often be found ripe when the æcidia on the same patches are also fully developed. They are inserted between the cells of the single layer of palisade cells when situated on the upper surface. They have a tuft of paraphyses protruding through their mouths, and measure about 0·107 m.m. in depth and breadth.

The *æcidiospores* are round orange-yellow bodies of very uniform size measuring 23 μ in diameter when recently wetted with water (Fig. 5, Pl. XIII.). The *peridial* cells are roughly hexagonal, adhere very firmly to one another, and measure about 26 × 16 μ. The centre of each cell contains orange-yellow matter like the contents of the æcidiospores (Fig. 4, Pl. XIII.).

Remarks.—There can be little doubt that this Æcidium is caused by a Puccinia, with all the characters of *Puccinia coronata*, which occurs on *Brachypodium sylvaticum* in Simla, but unfortunately I have not had sufficient opportunities of verifying this. So far as my insufficient experiments go, I have always obtained negative results. I am also not quite sure whether this Æcidium does not also occur on *Sageretia oppositifolia*.

6.—Puccinia Fragariæ, nov. sp.

Fragaria vesca, Linn.

During May, and just before it flowers, the Wild Strawberry, *Fragaria vesca*, may in some years be seen attacked by an æcidial fungus. This parasite is, however, a rare one, and I found it on two occasions only in 1885 at localities distant a few miles from one another, and on each occasion only a single affected plant was found. Æcidial fructification was found both on the petiole and on the leaf blade. It is somewhat curious that the same leaf bore *simultaneously* uredo and teleutospore pustules, but all the three forms of spore-pustules were quite distinct

from one another, with green normal tissue between them—at least, I could not trace any mycelial connection between them. The æcidial fructification consists of groups of æcidia on the margins of the leaves. The portions of the leaf blade bearing these quickly wither and dry up after the æcidia ripen. The æcidia break through both the upper and lower surfaces of the leaf, but more frequently from the lower. Spermogonia of the usual form are frequently present, especially on the petiole when this is affected, and they are placed usually close by the side of the æcidia.

The *æcidiospores* are pale yellow and very irregular in size and shape, varying from round to oval, often faceted and irregularly angular. Their average measurements when moistened are 22 × 15·8 μ. The epispore is finely punctated (Fig. 6, Pl. XIII.). Placed in a decoction of cow-dung (Brefeld) several in 24 hours threw out short germinal tubes of an average diameter of 5·3 μ, but the greater number of spores would not germinate.

The *uredospores* are oval or pear-shaped and pale yellow in colour (Fig. 7, Pl. XIII.). They are produced in little circular yellow pustules, which are situated on both surfaces of the leaf. The external surface of the epispore is beset with prominent tubercles. The moistened spores measured on an average 21 × 17 μ. Placed in a decoction of cow-dung, only two were found to have germinated on the 5th day, whilst those placed in water did not germinate at all (Fig. 8, Pl. XIII.). The *teleutospores* are contained in little black pustules situated close to the æcidial fructifications. They were produced on both the upper and lower surfaces of the leaf blade, but more frequently on the lower surface, as in the case of the æcidia. The spores are dark brown, two-celled bodies, puccinia, easily detached from their beds, breaking off with only a small fragment of stalk adhering (Fig. 9, Pl. XIII.). The average measurements of these spores when moistened were as follows:—whole length 31·7 μ; length of upper cell 15·8 μ, and breadth of same 22·4 μ; length of lower cell 15·8, and width of same 21 μ. The stalks bearing these spores are from 2 to $2\frac{1}{2}$ times the whole length of the spore. Amongst these teleutospores a few uredospores occurred of the characters above given. The teleutospores were sown in a decoction of cow-dung, as well as in water, but they did not germinate. On one occasion, in autumn (November), I found a single leaf of this plant plentifully covered with teleutospore-pustules. I did not succeed in getting them to germinate.

From want of sufficient material, I could not experimentally determine a genetic relationship between these different spores, but the close proximity of the teleutosporic sori to the æcidial fructification and

the occurrence of uredospores in the teleutospore-pustules lend some support to the view that we have here to do with a complete autoecious Uredine. However, in the absence of experimental evidence, this remains a mere presumption.

Remarks.—I believe that this is an entirely new species, and I have therefore named it *Puccinia Fragariæ*, in accordance with recognised precedent in nomenclature, although I should have preferred naming it *Æcidium Fragariæ*.

7.—Æcidium leucospermum, D. C. ?

Anemone rivularis, Ham.

This fungus is remarkably localised. During the last three years, although I have looked for it everywhere about Simla, and the host may be found everywhere, I have found it in only two localities, one in Simla (Annandale), the other in a forest (Cheog) about 14 miles distant. In these localities I have found it in June, July, and the beginning of August, before the plant flowers. The most striking peculiarity of this æcidium is that it is white. The whole leaf is often involved, though generally only well-defined portions are, and frequently the margin of the leaf (Fig. 11, Pl. XIII.). The æcidia break out almost entirely from the under surface, though a few may occasionally be seen on the upper surface. When a young immature leaf is attacked, as is often the case, there is a striking arrest of growth, the leaf never attaining the usual size shown by sister leaves of the same plant which are not affected—indeed, a fully affected young leaf is often only one quarter the normal size. The petioles were never seen to be attacked. Sometimes every leaf of a plant was found attacked. The attacked areas after the ripening of the æcidia quickly turn brown and wither.

The *æcidiospores*, when just wetted, are round or oval and measure on an average 17·7 × 15·6 μ. The epispore is beset with very minute tubercles (Fig. 12, Pl. XIII). I never succeeded in getting them to germinate in a growing cell. The peridial cells measure about 18 × 16 μ.

The *spermogonia*, formed only on the upper surface of the leaf, measure about 80 μ in depth and 120 μ in breadth. They are very superficially situated, having their bases sunk only through the epidermis and resting on the palisade cells. A tuft of paraphyses projects through their mouths about 40 to 50 μ in length.

Remarks.—*Puccinia Anemones*, Pers., occurs on *A. nemorosa* and *A. ranunculoides*, forming powdery masses of teleutospores (without uredospores) on the under surfaces of the leaves. Each of these hosts also bears an Æcidium, that on *A. ranunculoides* (*Æc. punctatum*, Pers.) having violet-brown æcidiospores and that on *A. nemorosa*

(*Æc. leucospermum*, D. C.) having white spores. Although I have carefully searched for teleutospores on *A. rivularis* in Simla, I have never found them, and I am therefore constrained to call this Æcidium *Æc. leucospermum* in the meantime. Schröter, I understand, thinks the teleutospores on *A. nemorosa* are related to the Æcidium borne on the same host, whilst Fuckel relates the Æcidium on *A. ranunculoides* with the teleutospores borne on it. The Himalayan Æcidium would appear to throw some doubt on the connection between their teleutospores (*Puccinia fusca*, Relhan) and the two æcidia, or, at any rate, if that be indisputable, the Himalayan Æcidium must be entirely different, being most probably a heteroecious Uredine.

8.—Æcidium Thalictri flavi, D. C.?

Thalictrum Javanicum, Blume.

The Æcidium on this plant, as in the case of that just described on Anemone, is remarkably localised, although the host is widely diffused. It is therefore a rare parasite, although, in the localities in which it is found, it occurs abundantly enough. It is met with during the rains, in July, while the plant is flowering. Only the leaf blades are as a rule affected, but occasionally the petiole is also attacked, when it is considerably hypertrophied and distorted. Fig. 1, Pl. XIV. represents the petiole attacked in two places: in both cases it will be seen that the petiole has become considerably elongated and in one case also bent completely round through 360°. When the parasite attacks the leaf blades, little reddish yellow spots are formed as seen from above, measuring ordinarily from a minute point to 4 or 5 m.m. in diameter. Sometimes, however, the patches are much larger—in one case 1 c. m. in diameter—and then the leaf is considerably distorted, especially when a main vein is involved. These larger patches are reddish brown above. The attacked areas are generally convex above at first, but often, as the area becomes larger, the converse obtains. The patches are frequently placed over a prominent vein, which is then, within the affected area, considerably swollen. The number of patches on a single leaflet varies from one to twelve or perhaps more. These attacked areas on the leaf blade are considerably thickened: the normal thickness of these delicate leaves is 0·095, m.m., whilst near a young still immature æcidium it was found to be 0·410 m.m.

Spermogonia are formed abundantly both on the upper and lower surfaces, and to the naked eye appear as minute pellucid reddish yellow spots. They are of the usual structure, measuring about 63 to 80 μ in depth and 75 to 94 μ in width. These structures are well sunk into the leaf tissue. Their mouths are surmounted by a tuft of paraphyses

about 60 to 65 μ in length. The tissues of the leaf are not so greatly hypertrophied in the spermogonial stage as they afterwards become, the depth of the laminal tissues near a ripe spermogonium being 0·189 m.m. in one case.

The *peridium* (Fig. 13, Pl. XIII) consists of a single layer of angular flattened cells measuring from 31·5 or 37·8 μ in length by 16 to 31 μ in breadth, or on an average 33·6 × 23·21 μ, shortly after immersion in water. It opens stellately. The *œcidiospores* are oval or round (Fig. 14, Pl. XIII.) reddish yellow bodies with a smooth epispore. The contents are either homogeneous or granular, more usually the latter. When just wetted, they measure about 25 μ in diameter, and the epispore is about 1·5 μ to 2 μ in thickness. They are given off serially as usual from basidia, but there are intermediate cells between succeeding spores (Fig. 15, Pl. XIII.).

Remarks.—It may not be out of place here to refer to a very fine Æcidium on *Thalictrum minus*, Linn., which I found on the 7th May 1884 at Urni, a village on the Hindustan-Thibet road about 126 miles from Simla towards the "Interior." It is quite possible that this is the same species as that which I have just described as found in Simla, but it gives rise to very considerably greater distortions and hypertrophies in its host. The attacked plants were indeed extremely distorted: sometimes a whole flower head exhibited a mass of small æcidial tubes (Fig. 16, Pl. XV.), and individual leaflets when largely invaded exhibited the most curious forms (Fig. 17, Pl. XV.). In this form, sometimes, though not very frequently, the stalk also was affected. The æcidiospores are orange-yellow, and measured, when dry, 19 × 16 μ on an average, but, when well moistened, 22 × 18 μ.

It is possible that both these forms are identical with, or varieties of, *Æcidium Thalictri flavi*, D. C., the æcidiospores of which are said to measure 17 to 28 μ long and 14 to 20 μ broad.

9.—Æcidium Jasmini, nov. sp.

Jasminum humile, Linn.

An Æcidium may be found on this plant during July and August, but is decidedly uncommon. The parasite attacks both leaf and petiole, but more commonly the leaf blade, giving rise to an irregularly circular patch, slightly paled above, greenish yellow and brownish red below. These patches vary in size, but are usually about 8 m.m. to 1 c. m. in diameter. The involved areas of the leaf are slightly thickened. The æcidia burst out exclusively from the under surface of the leaf, so far as my observations extend. They contain brilliant orange-yellow spores, the peridium, a short tubular structure, bursting at the summit in a

stellate manner. Spermogonia exist only on the upper surface, preceding the appearance of the æcidia by a very short time—indeed, while ripe spermogonia exist on the upper surface of a patch, young unopened æcidia may also be found on the lower surface of the same patch.

The *mycelium*, which ramifies between the parenchyma cells, is colourless. The bases of the spermogonia extend to the inner level of the palisade cells, and the bases of the æcidia from the other side reach down to the same point. The spermogonia measure about 126 μ in depth and 157 μ in breadth, and have a tuft of paraphyses projecting from the mouth to about 63 μ.

The *peridium* consists of a single layer of flat cells, more or less hexagonal and measuring about 26 × 22 μ (Fig. 2, Pl. XIV.). These cells are thick-walled and contain some yellow oil globules in their cavities.

The *æcidiospores*, after lying a few minutes in water, measured 26·2 × 20·2 μ on an average. Their contents are of a brilliant orange-yellow colour, and they have a thin epispore without any markings (Fig. 3, Pl. XIV.). I did not succeed in observing their germination, as they steadily refused to grow in water. The only other species of Jasmine common in Simla is *J. officinale*, L., but this host nevers bears an Æcidium, although the closely related *J. grandiflorum*, L., which grows at considerably lower elevations, harbours a very distinct and peculiar one, which I hope to describe later.

10.—Monosporidium Euphorbiæ, gen. et sp. nov.

Euphorbia cognata, Klotzsch.

Towards the end of July and during the first half of August, a very peculiar Æcidium on this plant presenting some very unusual characters is not uncommon; and some individual plants are very extensively attacked. Only the leaf blades are attacked, so far as I have observed, and a single leaf may exhibit from one to six patches of invasion. These patches are circular and rosy red above with a broad and irregular halo of paled yellowish tissue around them, the paling increasing in area as the patch grows older (Fig. 4, Pl. XIV.). On the under surface the patch is quite white and cushion like (convex). When very young, this cushion on the lower surface of the leaf is uniformly convex, and with a field lens a few pellucid spots may be seen in its centre, which are spermogonia. Later, as the spermogonia wither, a very distinct pit or depression is formed in the centre of the cushion, and, while this central pit enlarges in area, so the circular cushion surrounding it becomes more and more prominent and whiter. At last the central pit

is very distinct with now *black* points, the dried up spermogonia, over it (Fig. 4, Pl. XIV), and then the epidermis covering the surrounding cushion tears circularly near the external margin of the cushion and curls up inwards towards the centre disclosing a bed of white æcidiospores (*see* left-hand patch in Fig. 4, *a.* and *b.*). The *spermogonia*, which are extremely superficially placed (*see* Fig. 6, Pl. XIV.), are thus situated on the under surface of the leaf only. They are of the usual form and structure with a tuft of paraphyses protruding through the mouth. The whole organ, excluding the paraphyses, measures about 50 μ in depth and 100 μ in breadth. The *æcidiospores*, when just wetted with water, measure from 22 × 20 μ to 19 × 18 μ, the average of several measurements being 21 × 19·2 μ. The spores are colourless and almost round (Fig. 5, *a.* Pl. XIV.) with an epispore densely studded with minute tubercles. The distribution of the *mycelium* is peculiar and deserves description. In a section of a leaf passing through the æcidium, it will be seen that the mycelium lies mainly in two strands, one under the upper epidermis, between it and the palisade-cells, the other and larger under the lower epidermis, between it and the spongy cells (Fig. 6, Pl. XIV.). Moreover, the character of the layer of hyphæ under the upper epidermis is of a somewhat looser, more pseudo-parenchymatous character, than that under the lower epidermis (Fig. 7, Pl. XIV.). It should be noted that these layers of mycelial filaments are composed solely of hyphæ without any part of the host tissue being involved within them, and thus resemble strikingly the non-algal parts of lichens. The palisade-cells and spongy tissue between the two layers of mycelium are indeed extremely little affected or altered in any way. While in unaffected normal places the length of the palisade-cells is about 60 μ, and the depth of the spongy tissue layer about 50 μ, these measurements within attacked areas are about 56 μ and 36 μ, thus showing some diminution in size, especially in the spongy layer. The lower mycelial layer is about 50 μ in depth and the upper layer only 24 μ. The æcidial fructification is, as it were, inserted within the lower mycelial layer (*see* Fig. 6, Pl. XIV.), some strands passing above it and some below it. The *peridium* consists of a layer of cells about 32 × 30 μ in size, forming only a *roof* to the extremely large circular æcidium (*see* Fig. 6, Pl. XIV.). These cells are very loosely attached to one another, readily becoming isolated. Such an isolated cell is shown in Fig. 5, *b.* Pl. XIV ; and this figure also shows that it is beset externally with tubercles. The æcidiospores are given off in rows from a pseudo-parenchymatous hymenium without any well defined basidia, and have no intermediate cells between successive spores (Fig. 6, Pl. XIV.). The æcidiospores, as seen in rows in sections of leaves that have been hardened in absolute alcohol, are cubical (Fig. 6, Pl. XIV.).

The germination of these æcidiospores is very peculiar and unlike that of any other species with which I am acquainted, with the single exception of the æcidiospores of the Æcidium on another Euphorbiaceous plant *(Andrachne cordifolia)* described further on. I have not here, unfortunately, access to special memoirs on the development of individual Uredines, so that I am unable to state definitely that the mode of germination of these spores is altogether unknown, but, so far as I have been able to consult the works of others on this subject, I have not seen this mode described. The spores germinate fairly readily in water, throwing out the usual single germ-tube, measuring 5 μ in diameter (Fig. 7, Pl. XV.). After a time, from 24 to 48 hours, a secondary spore (sporidium ?) is formed at the end of the germ-tube, not upon any sterigma, but simply separated from the tube by a septum (Fig. 9, Pl. XV.). This secondary spore is round or oval, is double-contoured, and contains well defined granules in a mass of protoplasm (Fig. 9, Pl. XV.). They measure as a rule 14 μ in diameter. The day after the formation of this secondary spore, it germinates while still attached to the primary germ-tube, throwing out a secondary germ-tube which soon takes on a spiral form (Fig. 8, Pl. XV.). After this, the whole structure perishes, and I have not been able to determine its future history.

Remarks.—This Æcidium is evidently not *Æc. Euphorbiæ*, Gmelin, (or *Uromyces Pisi*, Pers.), as in this species the mycelium is described as pervading the whole plant or shoot, deforming all the leaves and preventing the formation of flowers on the shoots attacked. In the Æcidium above described, only local and well-defined areas of the leaves are attacked by the mycelium; the leaves are not altered in general shape, and the shoots bear flowers as usual. For much the same reasons this Æcidium is not *Uromyces scutellatus*, Lév., which also markedly deforms the leaves. It remains to consider its affinities with the genus Endophyllum and especially with *E. Euphorbiæ silvaticæ*, D. C., on *Euphorbia amygdaloides*, which is said to cause a well defined alteration in the leaves of the host, rendering them shorter and wider and somewhat fleshy, and discolouring them to a pale yellowish green colour. Moreover, this parasite has orange-yellow spores 16 to 26 μ long and 12 to 18 μ wide, whilst in the Simla Æcidium the spores are colourless or pale brownish and measure, as stated above, 22 $\times$ 20 μ to 19 $\times$ 18 μ. Moreover, the germination of the æcidiospores of the last mentioned Æcidium is different from that described in the case of Endophyllum, which is essentially of the nature of the germination of teleutospores. There is, however, some resemblance between the two Æcidia in this respect, for we may consider the secondary spore of the

Simla Æcidium to be of the nature of a sporidium, and then the only difference that exists between them is that, whilst in Endophyllum four deciduous sporidia are formed on sterigmata, in the Simla parasite only one non-deciduous one is produced directly at the end of the promycelium instead of at the end of a sterigma. But these differences are still great enough, I think, to entitle the species to be regarded as the type of a very distinct group of the Æcidiomycetes having its closest affinities with the genus Endophyllum. The only other Æcidium with which I am acquainted that would find a place in this new group or genus would be that which I have described further on on *Andrachne cordifolia*. I would define the characters of this new (provisional) genus as follows :—

Monosporidium, gen. nov.

Spore layer very like, or identically the same as, that of the Æcidia of Puccinia and Uromyces. The spores are abstricted in rows, but behave in germination somewhat like teleutospores in that the germ tube (promycelium ?) produces a secondary non-deciduous spore (sporidium ?) directly at its extremity without the intervention of a sterigma.

11.—Puccinia Graminis, Pers.

Berberis aristata, D.C.

During August, the Barberry may frequently be found attacked by an æcidium-bearing parasite. Only the leaves are attacked, and, on them, circular patches are formed, almost crimson-red on the upper surface with a narrow halo of pale yellow-green (Fig. 3, Pl. XV) and pale rosy red below with pale yellow æcidia thickly strewn over it. A single leaf may contain from one to six or eight such patches. A medium-sized patch measures from 4 to 5 m.m. in diameter (including the halo of yellow), but sometimes the patches exceed 1 c. m. in diameter. With a field lens, numerous spermogonia may be seen on the upper red surface, but also a few in the centre of the lower surface, around which the æcidia are arranged.

The *æcidiospores*, when just moistened, measure from 22 × 17 μ to 20 × 18 μ, or, on an average, 20·8 × 17·8 μ. The contents are bright orange-yellow, and usually on one side of the spore a colourless space is left filled apparently with colourless protoplasm (Fig. 8, Pl. XIV) giving a characteristic appearance to the spores. The peridial cells are generally square in outline and measure about 20 × 18 μ (*see* Fig. 9, Pl. XIV.). They are thick-walled, thicker on one side (Fig. 10, Pl. XIV.), and contain orange-yellow matter in their centres.

When invaded by mycelium, the leaf is generally considerably